PROCEEDINGS

OF

THE ROYAL SOCIETY.

1848. No. 72.

November 30, 1848.

At the Anniversary Meeting,

The MARQUIS OF NORTHAMPTON, President, in the Chair.

Professor Owen, on the part of the Auditors of the Treasurer's Accounts, reported, that the total receipts during the past year, including a balance of £636 11*s.* 3*d.*, carried from the account of the preceding year, amounted to £3303 12*s.* 3*d.*; and that the total expenditure, including £825 the cost of the £1000 three per cent. Consols, was £2818 19*s.* 2*d.*, leaving a balance of £484 13*s.* 1*d.* in the hands of the Treasurer.

The thanks of the Society were given to the Auditors for the trouble they have taken in examining the Treasurer's accounts.

The thanks of the Society were given to the Treasurer.

List of Fellows of the Royal Society deceased since the last Anniversary (1847).

On the Home List.

Sir James Annesley.
Sir Thomas Baring, Bart.
Sir John Barrow, Bart.
Lieut.-Col. Batty.
Major Brandreth.
Marquis of Bute.
Archbishop of Canterbury.
Robert Waring Darwin, M.D.
Edward Davies Davenport, Esq.
Thomas Kerigan, Esq.
Robert Liston, Esq.
Alex. MacLeay, Esq.
Captain Marryatt, R.N.
Viscount Melbourne.
Major Edward Moor.
Sir Thomas Neave, Bart.
John Spenser Smith, Esq.
Thomas Glanville Taylor, Esq.
James Watt, Esq.
William Archibald White, Esq.
Sir Giffin Wilson.

On the Foreign List.

Jean Jacob Berzelius.

Withdrawn.

Hon. Sir Edward Cust, K.H.

Defaulter.

Herbert Mayo, Esq.

List of Fellows elected into the Royal Society since the last Anniversary (1847).

On the Home List.

George Bishop, Esq.
Rev. James Challis.
Captain Henry Clerk, R.A.
William Fergusson, Esq.
Robert Were Fox, Esq.
Captain Henry James, R.E.
Robert Gordon Latham, M.D.
Capt. John Henry Lefroy, R.A.
James Ormiston M'William, M.D.
Thomas Oldham, Esq.
Robert Porrett, Esq.
Lyon Playfair, Esq.
John Stenhouse, Esq.
Allen Thomson, M D.

On the Foreign List.

Milne Edwards. | Carl Ritter.

The President, after returning thanks to the Royal Society for the honour conferred on him for ten years, delivered the Medals with the following words:—

Mr. Galloway,

I deliver this Royal Medal to you with great satisfaction, for your communication on one of the most interesting and difficult problems in Astronomy, the proper motion in space of our system; speculations which may almost seem too mighty and daring for the human intellect.

One who, like yourself, has entered on such a path of discovery, is not likely to turn from it. In further pursuing it, I feel assured that your zeal for the prosperity of the Royal Society will induce you to enrich our Transactions with other communications. Should my hopes prove well-founded, though my successor will, from his own pursuits, be much better able than myself to appreciate your labours, he will not be able to hail them with greater pleasure than myself.

Mr. HARGREAVE,

I am glad to deliver into your hands this Royal Medal for the mathematical paper with which you have enabled the Council to adorn the Philosophical Transactions.

It is a paper, from its nature indeed, more suited for the attentive study of the closet, than for reading before an audience, however scientific, but it is not on that account less valuable.

Mathematical analysis is doubly important: important in itself, and important as one of the great instruments of philosophical investigation. Every extension of it must then be at all times most highly welcome to a Society founded for the advancement of natural knowledge, and I, therefore, in its name, tender its thanks and an expression of the hope that it will not be the last communication that we shall receive at your hands.

Mr. ADAMS,

It is a great pleasure to me to be the channel by which the Council of the Royal Society gives you this Copley Medal.

In their award, I am sure that they have not done more than justice to the scientific zeal, industry, and skill exerted by you in the search of the great and distant body that caused the perturbations of the planet Uranus, a search crowned with success, both in your case and in that of your illustrious friend Le Verrier.

If he be an honour to his nation, not the less so are you to England; if he is a worthy follower of La Place, not less so are you of Newton. His name and yours will remain imperishably united in the annals of the glorious science which you both cultivate with so much zeal and so much success.

Lieut.-Col. SABINE,

I have to request of you, when transmitting to M. Regnault this Rumford Medal, to state to him the importance which the Royal Society attaches to his researches, determining with a degree of accuracy hitherto unobtained, the laws which govern the connexion between the temperature and elasticity of saturated steam, and the quantity of heat absorbed by a given weight of water under different densities and pressures.

The laws which govern the expansion of atmospheric air, under different pressures, and the expansion and densities of different gases and mercury, and the measurement of temperatures by these means, form in a series of memoirs altogether the most important investigations hitherto made on this subject.

Had the philosophical and philanthropical founder of this Medal been now living, I am sure that he would have cordially approved of the award of it to inquiries connected with the most important power that Providence has, as yet, given to man for lightening and assisting his industry, and for giving him speed for crossing sea and land, compared with which, the fabled wings of

Dædalus would have been comparatively useless. My only regret on the present occasion is, that M. Regnault is not here himself to receive this Medal.

The Statutes relating to the election of Council and Officers having been read by the Secretary, and Dr. Royle and Mr. Bennett having, with the consent of the Society, been nominated Scrutators to assist the Secretaries in examining the lists, the votes of the Fellows present were collected.

Mr. Bennett reported the following Noblemen and Gentlemen as being duly elected Officers and Council for the ensuing year:—

President.—The Earl of Rosse.

Treasurer.—George Rennie, Esq.

Secretaries. { S. Hunter Christie, Esq.
Thomas Bell, Esq.

Foreign Secretary.—Lieut.-Col. Edward Sabine, R.A.

Other Members of the Council.—George Biddell Airy, Esq., M.A.; Sir James Clark, Bart., M.D.; John P. Gassiot, Esq.; Thomas Graham, Esq., M.A.; William Robert Grove, Esq., M.A.; Leonard Horner, Esq.; Sir Robert H. Inglis, Bart., LL.D.; John George Shaw Lefevre, Esq., M.A.; Sir Charles Lyell, M.A.; William Allen Miller, M.D.; The Marquis of Northampton; Richard Owen, Esq.; John Phillips, Esq.; Peter Mark Roget, M.D.; the Dean of Westminster; Charles Wheatstone, Esq.

It was moved by Sir Robert Harry Inglis, Bart., seconded by Mr. Broughton, and resolved unanimously:—

That on this the last occasion of the Marquis of Northampton occupying the Chair of the Royal Society as its President, the special thanks of the Society be cordially tendered to his Lordship, for his able, zealous, and efficient discharge of the duties of that office for ten years.

On the motion of Dr. Paris, seconded by Professor Baden Powell, it was resolved unanimously:—

That the best thanks of the Royal Society be, and they are hereby given, to Dr. Roget for his continued and valuable services during a period of twenty-one years, in the office of Secretary to the Society.

The thanks of the Society were given to the Scrutators for their trouble in examining the lists.

The following is a statement of the Receipts and Expenditure during the past year:—

RECEIPTS.

	£	s.	d.
Balance in the hands of the Treasurer at the last Audit ..	636	11	3
Weekly Contributions, at one shilling 46 16 0			
Annual Contributions at £4 ..... 1076 0 0			
	1122	16	0
15 Admission Fees	150	0	0
1 Composition for Annual Payments at £40	40	0	0
One year's rent of estate at Mablethorpe: due at Michaelmas 1847 ..... 125 0 0			
One year's Income Tax 3 13 0			
	121	7	0
One year's rent of estate at Acton: due at Michaelmas 1848 ..... 70 0 0			
One year's Income Tax 2 0 10			
	67	19	2
One year's Fee farm rent of lands in Sussex: due at Michaelmas 1848	19	4	0
Dividends on Stock:—			
One year's dividend on £14,000 Reduced 3 per cent. Annuities 420 0 0			
Less Income Tax 12 5 0			
	407	15	0
One year's dividend on £8837 4s. 9d. 3 per cent. Consols 264 17 8			
Less Income Tax 7 10 0			
	257	7	8
Half a year's dividend on £1000 3 per cent. Consols 15 0 0			
Less Income Tax 0 8 9			
	14	11	3
Donation Fund.			
One year's dividend on £4843 14s. 7d. 145 6 2			
Less Income Tax 4 4 10			
	141	1	4
Rumford Fund.			
One year's dividend on £2430 12s. 5d. Consols 72 17 9			
Less Income Tax 2 1 9			
	70	16	0
Carried forward.....	3049	8	8

	£	s.	d.
Brought forward.....	3049	8	8
Fairchild Fund.			
One year's dividend on £100 New South Sea Annuities	3	0	0
Sir Clifton Wintringham's Bequest.			
One year's dividend on £1200 Consols 36 0 0			
Less Income Tax 1 1 0			
	34	19	0
Miscellaneous Receipts:—			
Sale of Philosophical Transactions, Abstracts of Papers, and Catalogues of the Royal Society's Library	216	4	7
Total Receipts.....	£3303	12	3

PAYMENTS.

	£	s.	d.
Fairchild Lecture.—The Rev. J. J. Ellis, for delivering the Fairchild Lecture for 1848	3	0	0
Bakerian Lecture.—Rev. W. Whewell for the Bakerian Lecture for 1848	4	0	0
Books purchased: £ s. d.			
Dulau and Co.: for Books 69 5 5			
Taylor: for ditto 35 2 9			
Nutt: for ditto..... 2 6 6			
Maynard: for ditto 2 15 6			
Wood: for ditto 7 7 0			
	116	17	2
Salaries:—			
Dr. Roget, one year, as Secretary 105 0 0			
S. H. Christie, Esq., one year, as Secretary.. 105 0 0			
Ditto for Index to Phil. Trans. 5 5 0			
Col. Sabine, one year, as Foreign Secretary.. 20 0 0			
Charles R. Weld, Esq., one year, as Assistant-Secretary and Librarian..... 300 0 0			
Mr. White, one year, as Attendant..... 80 0 0			
G. Holtzer, one year, as Porter 30 0 0			
Ditto, for extra Porterage 10 0 0			
	655	5	0
Purchase of £1000 3 per cent. Consols	825	0	0
Fire Insurance, on the Society's Property	45	1	6
Gratuity to Bank Clerks	1	1	0
Carried forward.....	1650	4	8

				£	s.	d.
Brought forward.....				1650	4	8
Bills:—						
Taylor:						
Printing the Phil. Trans., 1847, part 2 ..	144	16	3			
Ditto, 1848, part 1.....	106	10	9			
Ditto, Proceedings, Nos. 69—70; Circulars, Lists of Fellows, Ballot-lists, Statement of Payments, and Minutes of Council; &c. &c.	82	11	6			
				333	18	6
Basire:						
Engraving Plates in Transactions, 1847, part 2.....	5	12	0			
Ditto, 1848, part 1.....	105	7	10			
				110	19	10
Dinkel:						
For Lithography	22	10	0			
Maguire:						
For ditto	9	1	6			
				31	11	6
Bowles and Gardiner:						
Paper for the Phil. Trans., 1847, part 2, and 1848, part 1.....				80	17	0
Gyde:						
Boarding and Sewing 800 Parts of Phil. Trans., 1847, part 2	11	4	0			
Ditto, 1848, part 1.....	11	4	0			
Ditto, Extra binding	15	4	7			
				37	12	7
Tuckett:						
Bookbinding	38	18	0			
Limbird:						
For Stationery	18	0	11			
Saunderson:						
For Shipping Expenses	15	2	7			
Brecknell and Turner:						
Candles, and Lamp Oil	29	14	0			
Arnold:						
For Coals	27	12	0			
Gwillim:						
Mats, Brushes, Fire-wood, &c.	8	10	7			
Cubitt:						
For repairs and relaying Carpets, &c.....	9	14	7			
Halling:						
For Furniture.....	7	1	8			
Snell:						
For ditto	5	12	6			
Slack:						
For Repairs	6	8	7			
	166	15	5			
Carried forward.....				2245	4	1

	£	s.	d.	£	s.	d.
Brought forward..	166	15	5	2245	4	1
Kirtland:						
For Copying	5	6	0			
Shoolbred:						
For Curtains	3	15	3			
James:						
For Portrait of Galileo	8	0	0			
Salteri:						
For Frames	3	15	0			
Humphries:						
For Livery	11	0	0			
				198	11	8
Taxes:						
Land and Assessed Taxes	21	14	2			
Income Tax	4	19	2			
				26	13	4
Few and Co.:						
Law Expenses, 1843 to 1848				77	10	0
Rumford Fund:						
Mr. Wyon, for Medals	64	0	0			
M. Regnault, Balance of Dividends	77	12	0			
				141	12	0
Donation Fund:						
Mr. Miller, for Meteorological Instruments				30	0	0
Petty Charges:						
Postage and Carriage	31	16	11			
Expenses on Foreign Packets, &c.	11	0	11			
Stamps	1	5	0			
Charwoman's Wages	31	18	0			
Miscellaneous expenses	23	7	3			
				99	8	1
Balance in the hands of the Treasurer				484	13	1
Total....				£3303	12	3

GEORGE RENNIE, *Treasurer.*

November 30th, 1848.

The Receipts during the past year, exclusive of the Balance, amounted to:—£2667 1*s.* 0*d.*

The Expenditure during the same period, exclusive of the sum of £825 cost of £1000 Consols, was:—£1993 19*s.* 2*d.*

Estates and Property of the Royal Society.

Estate at Mablethorpe, Lincolnshire (55 A. 2 R. 2 P.). Rent £125 per annum.

Estate at Acton, Middlesex (33 acres). Rent £70 per annum.

Fee farm rent in Sussex, £19 4*s.* per annum.

One-fifth of the clear rent of an estate at Lambeth Hill, from the College of Physicians, £3 per annum.

£14,000 Reduced 3 per cent. Annuities.

£18,411 11*s.* 9*d.* Consolidated Bank Annuities.

The Balance in hand, now belonging to the Donation Fund is £587 2*s.* 7*d.*

The following table shows the progress and present state of the Society with respect to the number of Fellows:—

	Patron and Honorary.	Foreign.	Having compounded.	Paying £2 12*s.* Annually.	Paying £4 Annually.	Total.
November 1847....	13	47	481	18	262	821
Since elected.....	.....	+2	.....	.....	+14	+16
Since compounded	.....	.....	+1	.....	−1	
Defaulters.....	.....	.....	.....	.....	−1	−1
Withdrawn	.....	.....	.....	.....	−1	−1
Since deceased	.....	−1	−13	.....	−9	−23
November 1848....	13	48	469	18	264	812

Annual Contributions.

1830.....	£363	4	0
1831.....	286	0	0
1832.....	255	6	0
1833.....	283	7	6
1834.....	318	18	6
1835.....	346	12	6
1836.....	495	0	0
1837.....	531	0	0
1838.....	599	4	0
1839.....	666	16	0
1840.....	767	4	0
1841.....	815	12	0
1842.....	910	8	0
1843.....	933	16	0
1844.....	1025	16	0
1845.....	1010	0	0
1846.....	1074	0	0
1847.....	1116	8	0
1848.....	1122	16	0

December 7, 1848.

The EARL OF ROSSE, President, in the Chair.

The Rev. James Challis, George Bishop, Esq., Captain Clerk, R.A. were admitted into the Society.

The Marquis of Northampton gave notice that His Grace the Archbishop of Canterbury would be proposed at the next Meeting for election and for immediate ballot, to which, as a Spiritual Peer of the Realm, His Grace is entitled.

Dr. Faraday then delivered the Bakerian Lecture, illustrative of his paper, entitled "Experimental Researches in Electricity. Twenty-second Series. § 28. On the Crystalline Polarity of Bismuth and other bodies, and on its relation to the magnetic form of force."

In this paper the author states that in preparing small cylinders of bismuth by casting them in glass tubes, he had often been embarrassed by the anomalous magnetic results which they gave, and that having determined to investigate the matter closely, it ended in a reference of the effects to the crystalline condition of the bismuth, which may be thus briefly stated. If bismuth be crystallized in the ordinary way, and then a crystal, or a group of symmetric crystals, be selected and suspended in the magnetic field between horizontal poles, it immediately either points in a given direction, or vibrates about a given position, as a small magnetic needle would do, and if disturbed from this position it returns to it. On re-suspending the crystal so that the horizontal line which is transverse to the magnetic axis shall become the vertical line, the crystal then points with its maximum degree of force. If it be again re-suspended so that the line parallel to the magnetic axis be rendered vertical, the crystal loses all directive force. This line of direction, therefore, which tends to place itself parallel to the magnetic axis, the author calls the *Magne-crystallic axis* of the crystal. It is perpendicular, or nearly so, to the brightest and most perfect of the four cleavage planes of the crystal. It is the same for all crystals of bismuth. Whether this magne-crystallic axis is parallel or transverse to the magnetic axis, the bismuth is in both cases repelled from a single, or the stronger of two poles; its diamagnetic relations being in no way affected. If the crystal be broken up, or if it be fused and resolidified, and the metal then subjected to the action of the magnet, the diamagnetic phenomena remain, but the magnecrystallic results disappear, because of the confused and opposing crystalline condition of the various parts. If an ingot of bismuth be broken up and fragmentary plates selected which are crystallized uniformly throughout, these also point; the magnecrystallic axis being, as before, perpendicular to the chief plane of cleavage, and the external form, in this respect, of no consequence.

The effect takes place when the crystal is surrounded by masses of bismuth, or when it is immersed in water, or in a solution of sulphate of iron, and with as much force, apparently, as if nothing intervened.

The position of the crystal in the magnetic field is affected by the approximation of extra magnets, or of soft iron; but the author does not believe that this results from any attractive or repulsive force exerted on the bismuth, but only from the disturbance of the lines of force or resultants of magnetic action, by which they acquire as it were new directions; and, as the law of action which he gives, is, that *the line or axis of magnecrystallic force tends to place itself parallel, or as a tangent, to the magnetic curve or line of magnetic force, passing through the place where the crystal is situated*, so the crystal changes its position with any change of direction in these lines.

A common horse-shoe magnet exhibits these phenomena very well: the author worked much with one lifting 30lbs. by the keeper; but one that can raise a pound or two only, is sufficient for many of the actions. When using the electro-magnet, the advantage of employing poles with large plane opposed faces is mentioned as being considerable, for then diamagnetic phenomena are almost or entirely avoided and the peculiar magnecrystallic relations then appear.

The peculiar force exerted in these phenomena is not either attractive or repulsive, but has for its distinctive character the tendency to place the crystal in a definite position or direction. The author further distinguishes it from that described by M. Plücker in his interesting memoir upon the repulsion of the optic axes of crystals by the poles of a magnet*, in that, *that* is an equatorial force, whereas *this* is an axial force.

Crystals of *antimony* were then submitted to a similar magnetic examination, and with the same results. But there were also certain other effects produced of arrest and revulsion, the same in kind as those described in a former series of the 'Experimental Researches' (par. 2309, &c.); these are wrought out and eliminated, and the results described.

Arsenic also proved to be a body capable of pointing in the magnetic field, like bismuth and antimony.

The paper describing the foregoing results is dated 23rd of September, 1848. In a later paper of the date of 20th October, 1848, the author continues his researches. Native crystals of iridium and osmium, and also crystallized titanium and tellurium, appeared to be magnecrystallic: crystals of zinc, copper, tin, lead, gold, gave no signs of this condition. Crystals of sulphate of iron are very strongly affected by the magnet according to this new condition, and the magnecrystallic axis is perpendicular to two of the planes of the rhomboidal prism; so that when a long crystal is employed, it will not, as a mass, point between the poles, but across the line joining them. On the other hand, the sulphate of nickel has its magnecrystallic axis parallel, or nearly so, to the length of the ordinary prism. Hence bodies, both magnetic and diamagnetic, are, by their crystalline condition, subject to the magnetic force, according to the law already laid down. Diamond, rock-salt, fluor spar, boracite, red

* Poggendorff's Annalen, lxxii. Oct. 1847; or Taylor's Scientific Memoirs, vol. v. p. 353.

oxide of copper, oxide of tin, cinnabar, galena, and many other bodies, presented no evidence of the magnecrystallic condition.

The author then enters upon a consideration *of the nature of the magnecrystallic force*. In the first place he examines closely whether a crystal of bismuth has exactly the same amount of repulsion, diamagnetic or other, when presenting its magnecrystallic axis *parallel* or *transverse* to the lines of magnetic force acting on it. For this purpose the crystal was suspended either from a torsion balance, or as a pendulum thirty feet in length; but whatever the position of the magnecrystallic axis, the amount of repulsion was the same.

In other experiments a vertical axis was constructed of cocoon silk, and the body to be examined was attached at right angles to it as radius; a prismatic crystal of sulphate of iron, for instance, whose length was four times its breadth, was fixed on the axis with its length as radius and its magnecrystallic axis horizontal, and therefore as tangent; then, when this crystal was at rest under the torsion force of the silken axis, an electro-magnetic pole was so placed, that the axial line of magnetic force should be, when exerted, oblique to both the length and the magnecrystallic axis of the crystal; and the consequence was, that, when the electric current circulated round the magnet, the crystal actually *receded* from the magnet under the influence of the force, which tended to place the magnecrystallic axis and the magnetic axis parallel. Employing a crystal or plate of bismuth, that body could be made to *approach* the magnetic pole under the influence of the magnecrystallic force; and this force is so strong as to counteract either the tendency of the magnetic body to approach, or of the diamagnetic body to retreat, when it is exerted in the contrary direction. Hence the author concludes that it is neither attraction nor repulsion which causes the set, or determines the final position of a magnecrystallic body.

He next considers it as a force dependent upon the crystalline condition of the body, and therefore associated with the original molecular forces of the matter. He shows experimentally, that, as the magnet can move a crystal, so also a crystal can move a magnet. Also, that heat takes away this power just before the crystal fuses, and that cooling restores it in its original direction. He next considers whether the effects are due to a force altogether original and inherent in the crystal, or whether that which appears in it, is not partly induced by the magnetic and electric forces; and he concludes, that the force manifested in the magnetic field, which appears by external actions and causes the motion of the mass, is chiefly, and almost entirely *induced*, in a manner subject indeed to the crystalline force and additive to it, but at the same time exalting the force and the effects to a degree which they could not have approached without the induction. To this part of the force he applies the word *magneto-crystallic*, in contradistinction to the word magnecrystallic, which is employed to express the condition, or quality, or power, which belongs essentially to the crystal.

The author then remarks upon the extraordinary character of the power, which he cannot refer to polarity; and gives expression to

certain considerations and views which will be best learned from the paper itself. After this, he resumes the consideration of Plücker's results "*upon the repulsion of the optic axes of crystals*" already referred to, and arrives at the conclusion that his results and those now described have one common origin and cause. He then considers Plücker's results in relation to those which he formerly obtained with heavy optical glass and many other bodies. In conclusion he remarks, "How rapidly the knowledge of molecular forces grows upon us, and how strikingly every investigation tends to develope more and more their importance and their extreme attraction as an object of study! A few years ago magnetism was to us an occult power affecting only a few bodies; now it is found to influence all bodies, and to possess the most intimate relations with electricity, heat, chemical action, light, crystallization, and, through it, with the forces concerned in cohesion; and we may, in the present state of things, well feel urged to continue in our labours, encouraged by the hope of bringing it into a bond of union with gravity itself."

December 14, 1848.

Sir R. H. INGLIS, Bart., Vice-President, in the Chair.

The Chairman announced that the Earl of Rosse had nominated as Vice-Presidents—The Marquis of Northampton, The Dean of Westminster, George Rennie, Esq., G. B. Airy, Esq., W. R. Grove, Esq., Sir R. H. Inglis, Bart.

His Grace The Archbishop of Canterbury was elected into the Society.

The following paper was read:—

"On the effect of surrounding Media on Voltaic Ignition." By W. R. Grove, Esq., M.A., F.R.S.

The author refers to some experiments of his published in the Philosophical Magazine for December 1845, and in the Bakerian Lecture for 1847, relating to the difference of ignition generated in a platinum wire heated by the voltaic current, when the wire is immersed in atmospheres of different gases. In the present paper these experiments are continued, the current being passed through two platinum wires both in the same voltaic circuit, but immersed in atmospheres of different gases.

It appears from these experiments that the heat generated in the wire is less in hydrogen and its compounds than in other gases; and that when the wires and their atmospheres of gas are immersed in given quantities of water, the water surrounding the hydrogenous gases is less heated than that surrounding those which contain no hydrogen.

Similar experiments, in which the wires are immersed in different liquids, are then given; the heat developed appears not to depend on the specific heat of either the gases or the liquids.

The two series of experiments are brought into relation by one wire being immersed in hydrogen and the other in water, by which it appears that the cooling effect of the hydrogen nearly equals that of water.

Further experiments are then given, in order to ascertain, if possible, to what chemical or physical peculiarity these cooling effects are due; and from them it appears that they are not due to the specific gravity, specific heat, or to any conducting power of the gases for electricity; and that they do not follow the same law as that by which gases escape from minute apertures. They apparently depend upon some molecular character of the gases, by which either the interchange of hot and cold particles is facilitated, or a superficial action takes place, the surface of the hydrogenous gases presenting a more ready escape to the heat, similarly to that which has been long observed with regard to the different molecular constitutions of solid bodies, such for instance as the more rapid radiation or absorption of heat by black than by white surfaces, in the present case the epipolic action being dependent on the surface of the aëriform medium, and not on that of the solid substances.

December 21, 1848.

The DEAN OF WESTMINSTER, Vice-President, in the Chair.

A paper was in part read, entitled, "Contributions to the Physiology of the Alimentary Canal." By W. Brinton, Esq., M.B. Communicated by R. Bentley Todd, M.D., F.R.S.

The Society then adjourned over the Christmas recess, to meet again on the 11th of January next.

January 11, 1849.

The MARQUIS OF NORTHAMPTON, V.P., in the Chair.

The reading of a paper, entitled, "Contributions to the Physiology of the Alimentary Canal." By W. Brinton, Esq., M.B. Communicated by R. Bentley Todd, M.D., F.R.S., was resumed and concluded.

The paper consists of two parts, having a real relation to each other, though apparently little connected.

I. *On the Movements of the Stomach.*—The anatomy of its muscular coat is first briefly mentioned, and the so-called oblique fibres of some authors stated to be really transverse, *i. e.* at right angles to the altered direction of the canal.

The muscular actions of the digesting stomach are then considered.

These Haller regarded as alternate contractions in two directions, now forwards, now backwards, forcing the contained food in correspondingly reversed directions, and rested this conclusion on experiment and argument; but the author believes the experiment to be solitary, and not parallel with the fact sought to be established, and the argument to be inconclusive.

Beaumont's views are cited as analogous to Haller's, but are considered as having been by no means clearly stated.

The author indicates an argument from analogy, but chiefly bases his conclusion on the observations of Owen and others on Fishes, and his own observations in animals immediately after death:—in the empty or non-digesting stomach; and in the stomach which contains food; first, in the early stage of digestion; and, secondly, at a later period.

From a contrast of these three states it is found, that in the first there is no movement; in the second and third a considerable one; that in the latter, the opening of the pylorus, and the preponderance of the contractions of the pyloric half of the viscus, constitute its chief *distinction* from the second. The two latter movements are both peristaltic, or *in one direction only*—being *never* reversed, so far as the author has seen.

The movement impressed on the food is next considered. According to the observations of Beaumont and others, the food passes in two directions or streams, forwards and backwards. These observations the author has been unable to repeat, but regards them as established.

Assuming the truth of these observations, and contrasting them with the muscular actions previously stated, it appears that the latter are uniformly in *one* direction, the former in *two*,—an apparent incongruity, which the author next seeks to explain.

By experiment he attempts to imitate the natural conditions, and with the production of the like result. He next offers an explanation and illustration of the fact (which might almost be predicated, *à priori*), and adduces some (possible) analogues from the animal kingdom.

He then seeks to establish a general law—that transverse contractions, occurring in a closed tube filled with fluid, and proceeding in *one* direction only, imply *two* currents; a peripheral of advance, taking the same course as the peripheral contractions; and an axial of return, in the opposite direction.

He next points out the modification of this law for stomachs of human shape, and shows how compatible this is with the careful observations of Beaumont, none of which are essentially opposed to it.

The author indicates a probable modification correlative with the *consistence* of the food in some animals, and thus shows a dependence of this physical process on a previous one.

A solitary experiment is adduced to show that, as in the healthy movement, so also in vomiting, no backward or antiperistaltic contraction necessarily occurs.

A conjecture concerning regurgitation of fluid from the stomach concludes this part of the paper.

II. *On the Physiology of Intestinal Obstructions.*—In the preceding part of the paper it has been stated, that two currents probably obtain in the liquid contents of the stomach. Many of the conditions of the intestinal tube approximate to those of the stomach; and if disease or experiment add to these occlusion and distension, the analogy of the two organs is rendered tolerably complete, and the results will hence probably be referrible to the same general principle.

The most remarkable and constant symptom of this state of obstruction is the occurrence of fæcal vomiting.

The author briefly states the theory of an antiperistalsis by which this phenomenon is ordinarily explained: and from an inquiry into its experimental basis he deduces this general result, that an antiperistaltic movement has never yet been observed in any part of the alimentary canal. He regards the irregular actions seen on laying open the bellies of *healthy* animals recently killed, as not definedly peristaltic or the reverse, but as dependent on the irritation produced by the admitted air. So also, in the case of the *occluded* intestine, an inverted movement likewise fails to be recognized. In general, the vermicular actions are more energetic, and more peristaltic, than in the healthy bowel.

He next adduces the following arguments:—

1. The antiperistalsis is usually attributed to irritation; but irritation is present in almost every disease of the tube, while fæcal vomiting is limited to cases of obstruction. This renders it probable that the latter is the cause, and that the process of causation is, like the cause, *physical.*

2. The starting-point of the supposed inverted movement is the fullest part of the bowel, while the place towards which it has set is the emptiest. This condition is inconsistent with the supposition of an antiperistalsis, yet perfectly consistent with a forward movement, and analogous to the obstructions of other tubes conveying fluids.

3. Intus-susception is often the cause of obstruction. But, both from experiment and argument, it appears probable, that an antiperistalsis would at once remove this condition, and would therefore be incompatible with it.

4. The supposed inverted movement is continuous, while the vomiting is occasional. Hence a theory which showed the essential independency of the return of fæcal matters to the stomach, and their ejection thence, would be, so far, preferable.

5. Experiment and observation agree in showing that the ordinary peristalsis obtains immediately below the strangulation. And it is difficult to imagine how or why the same irritation should produce *two opposite* movements in *reversed* directions.

6. The general and comparative date of accession of the vomiting is scarcely compatible with the antiperistaltic theory.

The author next adduces experiments in which the intestine of animals was artificially occluded by a ligature. In exceptional cases,

the ligature sloughed into the canal, and the obstruction was thus destroyed. In all others, the tube was distended *above* the stricture to a variable extent. *Below* the stricture, the intestine was usually empty and contracted for an inch or two. The *contents* of the tube varied both in quality and quantity; uniform fluidity being associated with a large quantity of contents, while their smaller amount was often attended with differences of consistence. The date at which the vomiting acceded varied considerably. In one or two instances this symptom did not occur at all. These differences appeared mainly dependent on—

1. The amount of fluid ingesta,
2. The distance of the stricture from the stomach.

The date of death seemed to vary chiefly with the degree of distension.

He therefore deduces the theory,—That, in an obstructed intestine, a movement of the ordinary (and probably peristaltic) character propels the contents onwards to the seat of occlusion; that a continuance of the process distends, first this part of the tube, and next, those portions above it; that, if the contents are fluid, the ordinary peristalsis tends to develope an axial and reversed current, which returns matter from a lower to a higher point of the intestine;—often from the obstruction to the stomach, whence they are ejected by vomiting.

That in some cases, however, the action is probably much less perfect than this; the consistence of the contents preventing the perfection of these currents throughout the whole course of the tube. But still a mixture results, although a less intimate one.

The author next glances at the mode in which obstruction appears to affect peristalsis, and the nature of the distending fluid. He compares the obstructed intestine to the healthy stomach, to the obstructed artery and duct; referring its peculiar appearances to the dilatable yet muscular structure of its coats.

In conclusion, he indicates the possible result of this theory on practical medicine.

The following papers were also read:—1. "On the Determination of the Difference of Longitude, by means of the Magnetic Telegraph." By Elias Loomis, Esq., in a Letter to Lieut.-Col. Sabine, R.A., For. Sec. R.S. Communicated by Lieut.-Col. Sabine, R.A., For. Sec. R.S.

The writer first refers to a series of experiments made under the direction of Professor Bache, for the determination of the difference of longitude between New York, Philadelphia and Washington, by means of the magnetic telegraph. By this series of experiments he considers it established that, by means of Morse's telegraph, two clocks distant from each other 200 miles, can be compared together with the same precision as if they were placed side by side; and that the difference of longitude of two places can be determined with the same precision as the relative error of the clocks. These results were so satisfactory that Professor Bache determined to pro-

secute them more extensively, and during the past summer comparisons have been made between New York and Cambridge observatory near Boston. The plan of operation this season was more matured than during the former. The comparisons were all made between a solar chronometer at Cambridge and a sidereal clock at New York. At ten o'clock in the evening, the two observatories having been put in telegraphic communication, when the seconds hand of the solar chronometer came round to 60^s, a signal was given at Cambridge, by pressing the key of the telegraph-register; at the same instant a click was heard at New York, and the time was recorded according to the sidereal clock. At the end of 10^s a second signal was given, which was also recorded at New York; at the end of another 10^s a third signal was given, and so on for sixty seconds. The Cambridge astronomer then commenced beating seconds by striking the key of the telegraph-register in coincidence with the beats of his chronometer. The New York astronomer compared the signals received with the beats of his clock, and waited for a coincidence. When the beats were sensibly synchronous the time was recorded, and the astronomer waited six minutes for another coincidence of beats. The Cambridge astronomer continued beating seconds for *fifteen minutes*, during which time the New York observer was sure of two coincidences, and might obtain three. When these were concluded, the New York astronomer in the same manner gave signals for one minute at intervals of 10^s, and then beat seconds for fifteen minutes, during which time the Cambridge astronomer obtained four or five coincidences upon his chronometer. This mode of comparison was practised every night, and it is considered that the uncertainty in the comparison of the time-pieces cannot exceed two or three hundredths of a second on any night; and in a series of comparisons the error may be regarded as entirely eliminated.

Another mode of comparison which was practised is that of telegraphing star transits. A list of stars which culminate near our zenith at intervals of five or six minutes was prepared, and the observers, both at New York and Cambridge, were furnished with a copy. They then proceeded as follows: Cambridge selected two stars from the list, which we will call A and B, and struck the key of his register at the instant when the star A passed each of the seven wires of his transit. These signals were heard at New York, and the times recorded. Cambridge then observed the transit of star B in the ordinary manner without telegraphing. New York then observed the transit of star A on his meridian in the usual manner; and struck his key at the instant the star B passed each of the seven wires of his transit, which signals were heard and recorded at Cambridge. The difference of longitude between New York and Cambridge is nearly twelve minutes, affording ample time for all these observations. Thus New York obtained upon his own clock the times of transit of star A over the meridians of Cambridge and New York; and Cambridge obtained upon his chronometer the times of transit of star B over the same meridians. The difference of these times gives the dif-

ference of longitude independent of the right ascension of the stars. Both observers then reversed the axis of their transit instruments; Cambridge selected a second pair of stars from the list, and the same series of observations was repeated as with the first pair. The error of collimation was thus eliminated, and by confining the observations to stars within about five degrees of the zenith, the influence of azimuthal error was avoided. The level being read at every reversal, the correction for it was applied by computation. In this manner it is hoped to eliminate every possible source of error, except that which arises from the personal habits of the observers. In order to eliminate this error, a *travelling* observer worked for a time at Cambridge and compared with the Cambridge astronomer; then came to New York and compared with the New York astronomer; then returned to Cambridge again, and so on as often as was thought necessary. Finally, at the conclusion of the campaign all the observers were to meet at Cambridge and make a general comparison of their modes of observation.

On one or two nights the preceding programme was changed, and each observer telegraphed both star A and star B.

2. "On the peculiar cooling effects of Hydrogen and its compounds in cases of Voltaic Ignition." By W. F. Stevenson, Esq., F.R.S.

In this communication the author gives several theorems which he considers to be established by the experiments cited in a pamphlet which he published, entitled "The Non-decomposition of Water distinctly proved." He then states, that when we apply the principle of these theorems to Mr. Grove's discovery of the cooling properties of hydrogen, it will be found to admit of a most simple solution: "for instance, when the coil of platinum wire is connected with the poles of the electric battery, and the current is established, it is evident that the electric matter thus passed through the wire must escape at the contrary end (the air with which the wire is surrounded not being a conductor of electricity), and as the quantity of electric matter thus transmitted is considerable, and its exit from the wire confined but rapid, that commotion before noticed (in one of the author's theorems) necessarily ensues and causes the ignition of the wire; but when the coil of wire is immersed in hydrogen, which is a conductor of electricity, it is evident that the electric matter must be, at the same moment, abstracted or conducted from every portion of the wire, and consequently the commotion or rush of the electric matter at the extremity of the wire, which causes the ignition, is suspended and the comparative coolness of the wire is the necessary result."

3. Postscript to a paper "On the Ganglia and Nerves of the Heart," with two drawings. By Robert Lee, M.D., F.R.S.

The author states that since his former communication was presented to the Royal Society he has made a very minute dissection in alcohol of the whole nervous system of the young heifer's heart.

In this preparation the distribution of the ganglia and nerves over the entire surface of the heart, and the relations of these structures to the blood-vessels and muscular substance, are considered by the author to be far more fully displayed than in any of his former dissections. He states, that on the anterior surface there are distinctly visible to the naked eye, ninety ganglia or ganglionic enlargements on the nerves, which pass obliquely across the arteries and the muscular fibres of the ventricles from their base to the apex; that these ganglionic enlargements are observed on the nerves, not only where they are crossing the arteries, but where they are ramifying on the muscular substance without the blood-vessels; that on the posterior surface the principal branches of the coronary arteries plunge into the muscular substance of the heart near the base, and many nerves with ganglia accompany them throughout the walls to the lining membrane and columnæ carneæ.

The author considers that, in the accompanying beautiful drawings, Mr. West has depicted with the greatest accuracy and minuteness the whole nervous structures demonstrable in this preparation on the surface of the heart; but that the ganglia and nerves represented in these drawings constitute only a small portion of the nervous system of the heart, numerous ganglia being formed in the walls of the heart which no artist can represent.

4. "On the Aurora Borealis which occurred on the evening of Friday, the 17th of November, 1848." By Mr. R. Smith, Blackford, Perthshire. Communicated by P. M. Roget, M.D., F.R.S.

The author states that the 17th of November was a fine day with a clear sky and bright sunshine: towards evening the sky became cloudy and a few drops of rain fell, but it soon again became clear, with the exception of a few fleecy clouds that here and there dimmed its brightness. At $6^h\ 45^m$ a soft and gentle light began to illumine the northern region of the sky; and at 7 o'clock a considerable portion of it was covered with dark-red streams of light towards the east; while streamers moving to and fro, arrayed in colours of golden and silvery hues, overspread the south and north. About 8 o'clock there appeared near the zenith, and upon the magnetic meridian, a ring of an elliptical form, from which proceeded in all directions towards the horizon, beams or columns of light, giving to the heavens the appearance of a splendid vault, with its top adorned with a crown or wreath; while around and within the vault were to be seen clouds of brilliant light flashing towards and from the crown or central circle of the aurora, sometimes tinged with prismatic rays, at other times intensely white and lucid. About half-past nine nearly the whole of the aërial canopy was clad with clouds of a bright red colour, casting a curious reddened hue over the objects on the surface of the earth. After a short period of time had elapsed, the red colour began to diminish in intensity, and was again replaced by the white dome. However, in various parts of the sky the red colour still remained, principally in the north-west, south-west, and north-east. Between the hours of twelve and one beams

of brilliant white light commenced shooting up in the south from the horizon to the central ring or pole. The beams appeared to be at nearly equal distances from each other, the entire column of them stretching over a space equal to about one-fifth part of the visible horizon, in the form of a fan. The whole figure rapidly changed from a pure white light into a glow of brilliant colours of every tint, variegating the undulating waves as they rolled on their way to the pole of the aurora. In the course of three minutes these gave place to the white flashing radiations.

During the time of the aurora there were a great number of small meteors, the direction of whose motion was from east to west, and which appeared to be considerably below the sphere of the aurora.

A box containing a delicately balanced needle, was exposed upon the ground during the display of the aurora, but did not appear to be affected in the slightest degree till about one o'clock, when it was observed to be considerably deflected. At the time when the needle was disturbed, there was a dense column of radiating light in the north-west and south-east. The reflexion from the north-west was so clear, that when made to fall upon the polarizing plate of M. Biot's polarizing apparatus, and a film of mica was placed upon the stage of the instrument, the various colours produced by the mica were beautifully clear and distinctly seen in the analysing glass.

The author considers that the phenomenon of the colours which were noticed, was probably caused by exhalations or vapour floating in the atmosphere, betwixt the light of the aurora and the observer, causing a refraction of the rays transmitted to the eye, analogous to that which produces the phenomenon of halos. The continued undulations of the auroral light, and also the passing of the rays through thick and thin portions of the vapour, may, he considers, have produced the great variety of colours. During the time of the exhibition of this phenomenon, a thin fog or vapour was observed on both sides of the auroral fan. The author is of opinion that the cause which produced the variety of tints, is different from that which occasioned the red-coloured auroral clouds. At the time of the latter phenomenon the moon's position was nearly due east, and a cloud moved from the west towards the east, which in its course passed between the moon and the observer; as soon as the cloud obscured the light of the moon, the red colour to the north-west disappeared, but became visible when an opening in the cloud allowed the rays to pass through, and again vanished when another portion of the cloud cut off the light; and when the cloud had finally passed over, the red colour in the different parts of the sky resumed the same tint that it possessed before the moonlight was obscured by the cloud. The author states that it would thus appear, that when the light of the moon was incident at a certain angle upon the white light, or some kind of vapour that surrounded it, a red colour was produced; and hence that the moon is in some way or other connected with the phenomenon. He remarks, that the red colour was first observed in the east, and the moon being in that quarter of the heavens, the rays proceeding from it would first come in

contact with that part of the aurora towards the east. When the aurora commenced, the moon was considerably below the horizon; but this, it is considered, does not form any serious objection to what has been stated, since the aurora soared to so great a height, that the rays of light proceeding from her would strike the aurora a considerable time before she arose above the horizon.

The aurora continued for upwards of six hours, and during that time the thermometer stood at 34°.

January 18, 1849.

The MARQUIS OF NORTHAMPTON, V.P., in the Chair.

A paper was read, entitled "On the Development and Homologies of the Carapace and Plastron of the Chelonian Reptiles." By Professor Owen, F.R.S.

The author commences by defining the several parts of which the osseous thoracic-abdominal case of the Chelonian Reptiles is composed, and briefly discusses the several opinions that have been published with regard to their nature and homologies, dwelling chiefly on that recently proposed by Prof. Rathké, in his work on the Development of the *Chelonia*, in which it is contended that the carapace consists exclusively of the development of parts of the endo-skeleton, viz. the neural spines and vertebral ribs (*pleurapophyses*), agreeably with the opinion of Cuvier and Bojanus, and that the remainder of the thoracic-abdominal case, consisting of the "marginal pieces" and "plastron," are formed entirely from bones of the dermal system.

Adverting to the hypotheses of Cuvier, Geoffroy and Meckel, that the thoracic-abdominal case is a modification of parts of the endo-skeleton exclusively, the author tests their determinations by comparisons with the corresponding parts of the bird and crocodile, and infers, from the latter animal, that the hyosternal, hyposternal and xiphisternal bones are not parts of the sternum, but are homologous with the hæmapophyses (sternal ribs and abdominal ribs); those in the *Plesiosaurus* making the nearest approach to the peculiar development of the parts in the *Chelonia*, especially as they appear in the plastron of the immature Terrapenes and Sea-turtles.

Admitting that any hypothesis framed from the comparison of the completed structures in the adult Vertebrata requires for confirmation its agreement with the important phenomena of the development of those structures, the author proceeds to apply that test.

He details his observations on the development of the skeleton, and especially of the thoracic-abdominal case, in the embryos and young of different genera of *Chelonia*. The chief facts that have governed his conclusions are the following:—

With respect to the carapace. The cartilaginous basis of the neural plates is developed in the substance of the derm; and of

these, the 9th, 10th, 11th, and the 'nuchal' plate are ossified from independent centres, and remain permanently free from anchylosis with the subjacent spines of the vertebræ: they are, therefore, "dermal bones," homologous with those that overlie the vertebræ of the crocodile. But the first to the eighth neural plates inclusive are serial homologues with the foregoing, and must, therefore, have the same general homology. The objection that ossification extends into their dermal cartilaginous basis from the neural spines is met by the remark, that other parts, *e.g.* the radius and ulna of the frog, are ossified from a common centre, without their homological distinctness being thereby masked or destroyed. The course or starting-point of ossification does not determine the nature and homology of parts, and the author refers what he believes to be an erroneous conclusion of Prof. Rathké to undue value being given to the character of connation.

The cartilaginous basis of the costal plates is developed in the substance of the derm; the subjacent ribs are previously ossified and present the normal slender form. But ossification extends from near the head of each of the eight pairs of dorsal ribs, from the second to the ninth pair inclusive, into the superincumbent dermal cartilages. This had been described as the development of the tubercle of the rib. But Prof. Owen observes that, in the development of the carapace of the young of the *Testudo indica*, the connation of the costal plate with the rib commences at a different point in each rib alternately, and appears to be governed by the arrangement of the horny scutes above. Another objection to these ossific expansions being the tubercles of the ribs is presented by their abutment mesially against the neural plates, not against the vertebral diapophyses, as in the bird and crocodile.

In regard to the development of the plastron, the author describes two situations in which the primitive cartilages are developed, corresponding with those in the embryo-carapace, viz. one belonging to the endo-skeleton, the other in the derm. The first form under which the endo-skeletal parts of the plastron appear agrees with the evidence afforded by the comparison of the fully-developed parts with those of the crocodile, and proves the hyosternals, hyposternals and xiphisternals to be 'hæmapophyses' or abdominal ribs: the hyosternals and hyposternals are primitively long, slender, transverse bars, which join the vertebral ribs in the Tortoises and Terrapenes, without the intervention of any marginal pieces. The ossification of the superadded dermal portions proceeds from the previously ossified endo-skeletal elements.

The author concurs with M. Rathké in regarding the marginal pieces as 'dermal bones,' and concludes by a full discussion of the facts and arguments which have led him to a different conclusion respecting the nature and homologies of the carapace and plastron.

The memoir is illustrated by figures of the carapace and plastron, and of the corresponding segments of the skeleton in the bird and crocodile, and of the development of the thoracic-abdominal case in land- and sea-chelonians.

January 25, 1849.

Sir R. H. INGLIS, Bart., Vice-President, in the Chair.

The following papers were read:—1. Some remarks on a paper entitled "On the Depth of Rain which falls in the same localities at different Altitudes in the Hilly districts of Lancashire, Cheshire, &c., by S. C. Homersham, C.E." By John Fletcher Miller, Esq. Communicated by Lieut.-Col. Sabine, R.A., For. Sec. R.S.

The author, after alluding to the discordance between the conclusions at which he had arrived from a discussion of his meteorological observations in the lake district of Cumberland and Westmoreland, described in a former paper, and those drawn from the same facts by Mr. Homersham, in a paper read before the Society on the 25th of May last, states that the results for the year 1848 show a precisely similar gradation to those of the two preceding years; and that the whole of the observations appear to warrant the conclusion which he had ventured to draw from those detailed in his former paper.

He remarks that, as the rain-gauges are, with one exception, situated on the high mountains surrounding the head of the Vale of Wastdale, this valley is the only one which can fairly be selected as a standard in comparing the quantities of rain obtained at the different mountain stations. The discordance between his conclusions and those arrived at by Mr. Homersham, he considers, has arisen from that gentleman having selected the distant and excessively wet locality of Seathwaite at the head of the southern fork of Borrowdale, as a representative of the quantity of water deposited in the valleys generally.

If the receipts of the mountain gauges, he observes, be compared with the rain-fall at Wastdale Head, or in any of the other valleys except Seathwaite, it will be found that the quantity *increases* considerably up to 1900 feet, where it reaches a maximum; and that above this elevation it rapidly decreases, until at 2800 feet above the sea the amount is very much *less* than in the surrounding valleys.

In conclusion, the author states that it appears to him, that much of the discordance in the results obtained at various elevations amongst the mountains has arisen from the circumstance of the instruments having been placed on the slope or breast of the hill nearly in a line with each other; in which positions, he is convinced from experience, that when strong winds prevail, the gauges are exposed to eddies or counter-currents, which prevent a portion of the water from entering the funnel, and thus a less depth of rain is obtained than is due to the elevation.

The gauges under his superintendence being all stationed either on the top or shoulder of the mountain, and exposed to the wind from every point of the compass, are not, he observes, open to this objection.

2. Supplement to a paper "On the Theory of certain Bands seen

in the Spectrum." By G. G. Stokes, Esq., M.A., Fellow of Pembroke College, Cambridge. Communicated by the Rev. Baden Powell, M.A., F.R.S.

The principal object of the author in this communication is to point out some practical applications of the interference bands recently discovered by Professor Powell, the theory of which was considered by the author in the paper to which the present is a supplement. The bands seem specially adapted to the determination of the dispersion in media which cannot be procured in sufficient purity to exhibit the fixed lines of the spectrum. The ordinary experiments of interference allow of the determination of refractive indices with great precision; but in attempting to determine in this way the dispersion of the retarding plate employed, there is the want of a definite object to observe in connection with the different parts of the spectrum. In Professor Powell's experiment, the wire of the telescope, placed in coincidence with one of the fixed lines of the spectrum previously to the insertion of the retarding plate into the fluid, marks the place of the fixed line, and so affords a definite object to observe when the retarding plate is inserted into the fluid, and the spectrum is consequently traversed by bands of interference.

The practical applications considered by the author are principally four. In the first, the variation of the refractive index of the plate in passing from one fixed line to another is determined, the absolute refractive index for some one fixed line being supposed accurately known. The observation consists in counting the number of bands seen between two fixed lines of the spectrum, the fractions of a band-interval at the two extremities being measured or estimated.

In the second application, the absolute refractive index of the plate is determined for some one fixed line of the spectrum. The observation consists in counting the number of bands which move across the wire of the telescope, previously placed in coincidence with the fixed line in question, when the plate is inclined to the incident light.

The third application is to the determination of the change in the refractive index of the fluid, for any fixed line of the spectrum, produced by a change in the temperature. The observation consists in counting the number of bands which move across the wire of the telescope while the temperature sinks from one observed value to another, the temperature being noted by means of a delicate thermometer which remains in the fluid. For this observation a knowledge of the refractive index of the retarding plate is not required.

The fourth application is to the determination of the change of velocity of the light corresponding to any fixed line of the spectrum, when the direction of the refracted wave changes with reference to certain fixed lines in the plate, which is here supposed to belong to a doubly refracting crystal. The observation consists in counting the bands as they pass the wire when the plate is inclined. It requires that the plate should be mounted on a graduated instrument. It would be possible in this way to determine, by observation alone, the wave surface belonging to each fixed line of the spectrum.

While considering the theory of Professor Powell's bands, the author was led to perceive the explanation of certain bands, described by Professor Powell, which are seen in the secondary spectrum formed by two prisms which produce a partial achromatism. Although the account of these bands has been published many years, they do not seem hitherto to have attracted attention. It is easily shown by common optics that when two colours are united by means of two prisms, the deviation, regarded as a function of the refractive index, the angle of incidence being given, is a maximum or minimum for some intermediate colour. For the latter colour, two portions of light of consecutive degrees of refrangibility come out parallel; and therefore the diffraction bands belonging to different kinds of light, of very nearly the same refrangibility with the one in question, are superposed in such a manner that the dark and bright bands respectively coincide. Thus distinct bands are visible in the secondary spectrum, although none would be seen in the spectrum formed by a single prism, in consequence of the mixture of the bright and dark bands belonging to different kinds of light of nearly the same degree of refrangibility. The diffraction bands here spoken of are of very sensible breadth, in consequence of the small width of the aperture employed in the actual experiment.

When a spectrum is viewed through a narrow slit half covered by a plate of mica, the edge of which bisects the slit longitudinally, and is held parallel to the fixed lines of the spectrum, the bands described by Sir David Brewster are seen, provided the mica plate lie at the side at which the blue end of the spectrum is seen, and provided the thickness of the plate and the breadth of the slit lie within certain limits. When these bands are invisible in consequence of the slit being too narrow, or the spectrum too broad, it follows from theory that the bands ought to appear when the slit and plate are turned round the axis of the eye, so that the edge of the plate is no longer parallel to the fixed lines of the spectrum. The author has verified this conclusion by experiment, employing plates adapted to observations with the naked eye, which are best suited to the purpose.

February 1, 1849.

GEORGE RENNIE, Esq., Treasurer, Vice-President, in the Chair.

The following paper was read:—"On the Chemistry of the Urine;" in three Parts. By H. Bence Jones, M.D., M.A., F.R.S.

Part I. *On the variations of the Acidity of the Urine in Health.*

The mode of examination adopted by the author was the following: Two test solutions were made; the one with carbonate of soda; the other with dilute sulphuric acid, of such strength that each measure of a graduated tube, when filled with either solution, was equivalent to one-twelfth of a grain of dry and pure carbonate of soda.

A weighed quantity of urine was neutralized by one or other of

the test solutions, and thus the degree of acidity or alkalescence was determined.

Diurnal variations in the acidity of the urine were observed. The acidity of the urine was found to ebb and flow; it was greatest a short time before food was taken, and was least about three hours after breakfast, and five or six hours after dinner, when it reached the minimum point; after which it again increased, and attained the maximum point previous to food being again taken.

If no food was taken, the acidity varied but slightly for twelve hours.

By comparing the effect of vegetable food with animal food, it appeared that the food which irritated the stomach most and caused most secretion of acid in the stomach, caused the greatest oscillations in the urine.

Dilute sulphuric acid taken in large doses produced but little effect on the variations of the acidity of the urine; but it was proved to increase the acidity of the urine.

Part II. *On the simultaneous variations of the amount of Uric Acid and the Acidity of the Urine in a healthy state.*

The result of these experiments is, that there is no relation between the acidity of the urine and the amount of uric acid in it. The urine that was most acid contained least uric acid; that which contained most uric acid was not most acid. All food causes an increase in the amount of uric acid in the urine; and there is no decided difference between vegetable and animal food, either as to the increase or diminution of the amount of uric acid in the urine.

Part III. *Variations of the Sulphates in the Urine in the healthy state, and on the influence of Sulphuric Acid, Sulphur and the Sulphates, on the Sulphates in the Urine.*

The result of these experiments is, that the sulphates in the urine are much increased by food, whether it be vegetable or animal. Exercise does not produce a marked increase in the sulphates. Sulphuric acid, when taken in large quantity, increases the sulphates in the urine. In small quantity, even when long-continued, no effect on the amount of sulphates is manifest.

Sulphur taken as a medicine increases the sulphates in the urine. Sulphate of soda and sulphate of magnesia produce the most marked increase in the sulphates in the urine.

February 8, 1849.

The EARL OF ROSSE, President, in the Chair.

A paper was read, entitled "On the application of the Theory of Elliptic Functions to the Rotation of a Rigid Body round a Fixed Point." By James Booth, L.L.D., F.R.S.

In the introduction to his investigation, the author, after noticing the investigations of D'Alembert and Euler, and the solution of this

problem by Lagrange, refers more particularly to the memoir of Poinsot, in which the motion of a body round a fixed point, and free from the action of accelerating forces, is reduced to the motion of a certain ellipsoid whose centre is fixed, and which rolls without sliding on a plane fixed in space; and likewise to the researches of Maccullagh, in which, by adopting an ellipsoid the reciprocal of that chosen by Poinsot, he deduced those results which long before had been arrived at by the more operose methods of Euler and Lagrange; observing, however, that it is to Legendre that we are indebted for the happy conception of substituting, as a means of investigation, an ideal ellipsoid having certain relations with the actually revolving body. He then states, that several years ago he was led to somewhat similar views, from remarking the identity which exists between the formulæ for finding the position of the principal axes of a body and those for determining the symmetrical diameters of an ellipsoid; and further observing that the expression for the perpendicular from the centre on a tangent plane to an ellipsoid, in terms of the cosines of the angles which it makes with the axes, is precisely the same in form as that which gives the value of the moment of inertia round a line passing through the origin. Guided by this analogy, he was led to assume an ellipsoid the squares of whose axes should be directly proportional to the moments of inertia round the coinciding principal axes of the body. This is also the ellipsoid chosen by Maccullagh. Although it may at first sight appear of little importance which of the ellipsoids—the *inverse* of Poinsot, or the *direct* of Maccullagh and the author—is chosen as the geometrical substitute for the revolving body, it is by no means a matter of indifference when we come to treat of the properties of the integrals which determine the motion. Generally those integrals depend on the properties of those curves of double flexure in which cones of the second degree are generally intersected by concentric spheres; and it so happens that the direct ellipsoid of moments is intersected by a concentric sphere in one of these curves. By means of the properties of these curves a complete solution may be obtained even in the most general cases, to which only an approximation has hitherto been made.

In the first section of the paper, the author establishes such properties as he has subsequently occasion to refer to, of cones of the second degree, and of the curves of double curvature in which these surfaces may be intersected by concentric spheres, some of which he believes will not be found in any published treatise on the subject. He considers that he has been so fortunate as to be the first to obtain the true representative curve of elliptic functions of the first order. It is shown that any spherical conic section, the tangents of whose principal semiarcs are the ordinates of an equilateral hyperbola whose transverse semiaxis is 1, may be rectified by an elliptic function of the first order; and the quadrature of such a curve may be effected by a function of the same order, when the cotangents of the halves of the principal arcs are the ordinates of the same equilateral hyperbola.

This particular species of spherical ellipse the author has called the "Parabolic Ellipse," because, as is shown in the course of the investigation, it is the gnomonic projection, on the surface of a sphere, of the common parabola whose plane touches the sphere at the focus. As in this species of spherical ellipse either the focus or the centre may be taken as the origin of the spherical radii vectores, in effecting the process of rectification, we are unexpectedly presented with Lagrange's scale of modular transformations, as also with the other equally well-known theorem by which the successive amplitudes are connected. Among other peculiar properties of the spherical parabolic ellipse established in this paper, it is shown that the portion of a great circle touching the curve, and intercepted between the perpendicular arcs on it from the foci, is always equal to a quadrant.

In the second and following sections, the author proceeds to discuss the problem which is the immediate subject of the paper. Having established the ordinary equations of motion, he shows that, if the direct ellipsoid of moments be constructed, the motion of a rigid body acted on solely by primitive impulses may be represented by this ellipsoid moving round its centre, in such a manner that its surface shall always pass through a point fixed in space. This point, so fixed, is the extremity of the axis of the plane of the impressed couple, or of the plane known as the invariable plane of the motion.

But a still clearer idea of the motion of such a body is presented in the subsequent investigations, it being there shown, that the most general motion of a body round a fixed point may be represented by a cone rolling with a certain variable velocity on a plane whose axis is fixed, while this plane revolves about its own axis with a certain uniform velocity. This cone may always be determined. For the circular sections of the invariable cone coincide with the circular sections of the ellipsoid of moments; whence the cyclic axes of the ellipsoid, or the diameters perpendicular to the planes of these sections, will be the focal lines of the supplemental cone; and as the invariable plane is always a tangent plane to this cone, we have sufficient elements given to determine it.

From these considerations it appears that we may dispense altogether with the ellipsoid of moments, and say that if two right lines be drawn through the fixed point of the body in the plane of the greatest and least moments of inertia, making angles with the axis of greatest moment, the cosines of which shall be equal to the square root of the expression

$$\frac{L(M-N)}{M(L-N)},$$

(L, M, N being the symmetrical moments of inertia round the principal axes) and a cone be conceived having those lines as focals, and touching moreover the invariable plane, the motion of the body will consist in the rotation of this cone on the invariable plane with a variable velocity, while the plane revolves round its own axis with an uniform velocity.

Although it is very satisfactory, the author remarks, in this way

to be enabled to place before our eyes, so to speak, the actual motion of the revolving body, yet it is not on such grounds that the paper is presented to this Society. It is as a method of investigation that it must rest its claims to the notice of mathematicians; as a means of giving simple and elegant interpretations of those definite integrals on the evaluation of which the dynamic state of a body at any epoch can alone be ascertained.

In these applications of the theory of elliptic functions, the author has been led to the remarkable theorem, that the length of the spiral, between two of its successive apsides, described in absolute space on the surface of a fixed concentric sphere, by the instantaneous axis of rotation, is equal to a quadrant of the spherical ellipse described on an equal sphere moving with the body, by the same instantaneous axis of rotation.

The last section of the paper is devoted to the discussion of that particular case in which the axis of the invariable plane is equal to the mean semiaxis of the ellipsoid of moments.

February 15, 1849.

W. R. GROVE, Esq., Vice-President, in the Chair.

A paper was in part read, entitled "Description of an Infusory Animalcule allied to the genus Notommata of Ehrenberg, hitherto undescribed." By John Dalrymple, Esq., F.R.C.S. Communicated by Thomas Bell, Esq., Sec. R.S.

February 22, 1849.

GEORGE RENNIE, Esq., Treasurer, Vice-President, in the Chair.

The Right Honourable Sir Francis Baring, Bart., First Lord of the Admiralty, was balloted for and duly elected into the Society.

The reading of a paper, entitled "Description of an Infusory Animalcule allied to the genus Notommata of Ehrenberg, hitherto undescribed." By John Dalrymple, Esq., F.R.C.S. Communicated by Thomas Bell, Esq., Sec. R.S., was resumed and concluded.

The examination of various specimens of the animalcule described by the author, disclosed the dicœcious character of one of the more highly organized of the rotiferous class of Infusoria, hitherto supposed to be androgenous. This discovery was first made by observing the difference in the form and development of the embryo while still enclosed in the ovisac of the parent animal. From the extreme transparency of this form of rotifer, it is possible to trace the progressive development of the young from the Græffian vesicle in the ovary to the period of mature gestation, when the embryo is

expelled, the whole machinery of whose organs has been perfected while still within the body of the female.

Thus, although the young one observed in the ovisac, when nearly ready to be expelled, was in the great majority of instances a miniature portrait of the parent, yet occasionally an embryo was seen of a different aspect, within whose body a vesicle was discovered filled with actively moving spermatozoa.

A further investigation of the subject brought clear evidence of the functions performed by this male,—its copulation with the young females; but it also displayed the singular fact, that although the organs of reproduction and locomotion were highly developed, there was a total absence of those of assimilation; in fact, that neither mouth, nor stomach, nor other digestive cavity or glands, were present in its curious organization.

In the early part of the paper the author describes the anatomy of the female, which differs from the family of Notommata of Ehrenberg, in the absence of intestine and anal orifice, and forcipated or caudal foot. In every other respect the organization is so similar to that class, that the author believes the proper place for this animalcule to be in a *sub-genus* of Notommata.

In relation to physiology, the author submits a new theory of the mechanism of circulation and respiration in the general group of Rotifers, a subject which is but obscurely treated of by the great German observer, who appears to have believed in the existence of tubular vessels or true vascular system. The author thinks, however, that these functions are performed in a manner more resembling that of insects, viz. that the blood is contained in the general cavity of the animal and circulates round the lung, which is here represented by a contractile vesicle that receives and expels the water in which the animalcule lives, and so comes to be in intermediate relation with the air mixed with the water. The difference therefore between the aëration of the blood of insects and that of this rotifer is rather due to the difference of the media they respectively inhabit, than of design. In both, the blood is contained in a general cavity and brought in contact with the air, without the intervention of any true vascular system.

The beautiful transparency of the animal, and the facility with which the development of the ovum may be traced through all its stages, induces the author to believe it to be well-suited to the inquiries of the embryologist and of those who devote themselves to the study of the metamorphosis of cell into tissue.

This animalcule has hitherto been discovered only in a few situations (in Norfolk near Norwich, and in Warwickshire near Coventry), but it is believed, from the very general dispersion of Infusoria, that it may be more extensively met with, especially in the months of June, July, August and beginning of September.

The author concludes by expressing his belief that re-examination of the whole order of Rotifera is necessary to determine the disposition of the sexes, and to assign them their proper situation in the scale of animated beings.

A paper was also read, entitled "On the Integration of Linear Differential Equations." By the Rev. Brice Bronwin. Communicated by C. J. Hargreave, Esq., F.R.S.

The method chiefly employed in this paper, is analogous to one which the author had previously applied (Camb. Math. Journal, No. 4) to the integration of such equations in cases where the coefficients are integer functions of the independent variable. Here they are any functions of that variable, it being however understood that in all integrable cases there must be some relation among these coefficients. The integration is effected by a general theorem of the form

$$\mathrm{D}^n f(\varpi_{m+n})u = f(\varpi_m)\mathrm{D}^n u,$$

where D denotes any function of x, and ϖ a function of symbols both of operation and quantity. By means of this theorem, and the substitution $u = \varpi_1 \varpi_2 \ldots \varpi_n v$, or some other similar one, the equation is either reduced to an integrable form, or to an equation of a lower order; or, when neither of these objects can be accomplished, the method may be employed to effect a transformation.

The method applies most readily to equations of the second order; but may be applied to those of a higher order, the coefficients becoming more restricted as the order rises. The integrable cases are very numerous and vary considerably in form; and, as each distinct form requires a variation in the process, they are distributed into classes. In each class, a few particular examples, derived from the general cases, are given.

By means of the general theorem, the equation

$$\varpi_m \varpi_n u + p\rho u = \mathrm{X}$$

may be integrated in the most general case, or when the coefficients are any functions of x, having, however, certain relations between them.

Several theorems of the form $\pi_n \rho u = \rho \pi_{n-1} u$, where $\rho = \mathrm{D} + \theta$, $\pi_n = \mathrm{D}^2 + \mathrm{A}_n \mathrm{D} + \mathrm{B}_n$, or similar to it, are given. They are not found without difficulty; are much more restricted in their application than the general theorem; and lead to but few results; but they are deserving of notice on the ground that they may possibly succeed in a particular case when all other methods fail.

A few general examples of a class of equations, the solution of which is attended with considerable difficulty, are next given. These are of the forms,

$$\mathrm{D}\varpi^2 u + b\varpi^2_n u = \mathrm{X}, \quad \mathrm{D}^2\varpi^2_n u + b\varpi^2_{n+m} u = \mathrm{X},$$

and others varying a little from them.

The concluding part of the paper is occupied with the transformation and application of one or two of the general theorems which have been given by the author in the Cambridge Mathematical Journal, New Series, vol. iii., from which a few examples, more or less particular, have been derived.